**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

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| Application No. | : | 10/783,386 |
| Applicants | : | Larry F. Rhodes et al. |
| Filed | : | February 20, 2004 |
| Title | : | Dissolution Rate Modifiers for Photoresist Compositions |
| Group Art Unit | : | 1752 |
| Examiner | : | Amanda C. Walke |
| Confirmation No. | : | 6408 |
| Customer No. | : | 28989 |

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**DECLARATION UNDER 37 C.F.R. § 1.132**

Sir

1. I, Larry F. Rhodes, am one of the named inventors of the invention described and claimed in the above-identified application for letters patent.

2. I am a citizen of the United States and reside at 3036 Vincent Road, Silver Lake, OH 44224. I graduated from the University of North Carolina in 1980 with a B.S in chemistry and from Indiana University in 1984 with a Ph.D. in chemistry. From 1984-1986, I was a post-doctoral student at the Laboratorium für Anorganische Chemie, Swiss Federal Institute of Technology (ETH-Zentrum) in Zurich, Switzerland. From 1986-1988, I was a post-doctoral student in the Chemistry Department at The Ohio State University in Columbus, OH. From 1988 to 2001, I was employed by BFGoodrich Company. In 2001, Sumitomo Bakelite purchased this portion of BFGoodrich (to become Promerus Electronic Materials). From 2001 to the present, I have been employed with Promerus Electronic Materials, Research and Development Center in Brecksville, OH and am currently a research fellow.

3. I am the author/co-author of over eighty (80) technical articles and the inventor/co-inventor of over forty (40) patents/patent applications, the large majority of which being directed to the polymerization of norbornene-type monomers and the use of such polymers (see, Exhibit A).

4. I have read and am thoroughly familiar with the contents of the above-identified patent application, as well as the prior art cited by the Examiner, namely, Willson et al. (hereinafter "Willson") (Polymeric materials journal article) and U.S. Patent Application No. 2004/0265738 to Feiring et al.

5. By way of background, and as shown in the attachment denoted as Exhibit B, I attest that the International Union of Pure and Applied Chemistry (IUPAC) provides definitions of the terms "polymer" and "oligomer" that are unambiguous and distinct from one another.

6. Further, as shown in the attachment denoted as Exhibit C, I attest that photolithography, as employed in the manufacture of Integrated Circuits, uses a photoresist layer disposed over a substrate to form a three-dimensional relief image that is a replica of the opaque and transparent areas present on a mask or reticle; such replica serving to protect certain regions of the underlying substrate from the effects of a subsequent process. (See, C-1)

7. I attest that it is well known, as shown in Exhibit C at C-2 and C-3, that the essential attributes of a photoresist include: (1) uniform, defect-free films on a substrate, i.e., no precipitation, which is especially challenging for ultra-thin films; (2) sufficient adhesion and cohesion, which is achieved through exposure, bake, develop and transfer steps; (3) high radiation sensitivity, i.e., throughput; (4) high fidelity reproduction of mask, i.e., high resolution and contrast; (5) good etch resistance, i.e., pattern transfer; and (6) readily removed, i.e., stripped; and to achieve these attributes a photoresist composition includes one or more additives (in addition to the polymeric binder resin), such as base quenchers, plasticizers, dissolution rate modifiers and crosslinkers (negative tone); a photoacid generator also referred to as a photoacid compound (PAG or PAC); and a solvent (vehicle for application).

8. Additionally, I attest that when a person of skill in the art contemplates preparing a chemically amplified positive-tone resist binder resin, the following design considerations (among others) will be used: (1) hydrophilicity- for good positive tone development characteristics; (2) a high glass transition temperature (Tg) (130-170oC)- for good thermal properties and high post-exposure bakes; and (3) easily protected hydroxyl group- for

incorporation of acid-cleavable functionality. With regard to a high Tg, such is needed since chemically amplified resists need a bake step after the image-wise exposure step to induce thermal deprotection of protected acid groups to render the exposed region of the resist soluble in aqueous base. (See, C-4 and C-5) I further attest that it is common knowledge in the art of polymer chemistry that the molecular weight of a polymer has a direct effect on the polymer's Tg. In particular, Tg decreases dramatically below the "entanglement" molecular weight and polymers lose properties such as mechanical strength. (See, C-6)

9. I attest that as shown in Exhibit C, at C-7 and C-8, typical molecular weights for 248 nm photoresist binder resins usually range from 11,000 to 20,000, and as shown at C-9, it is well known that for 193 nm poly(methacrylate)-based binder resins, photoresist polymers of "low" molecular weight do not allow good imaging performance and therefore are unsuitable as photoresist polymeric binder resins.

10. Still further I attest that the present invention, recited in Claim 1, is directed to a dissolution rate modifier (DRM) and NOT a photoresist binder resin or composition. Further that such DRM comprises, among other things, cyclic olefin-based oligomers derived from monomers in accordance with one or more of Formulae A, B or C (which are norbornene-type monomers) and Formulae D or E (which are allylic-type monomers); where such oligomers have a weight average molecular weight ($M_w$) of less than about 3,000.

***Therefore, I declare that:***

A. Willson discloses polymers that are employed as photoresist binder resins within photoresist compositions, whereas the claimed invention is directed to oligomers that are useful as dissolution rate modifiers (DRM) that may be added to a photoresist composition. That the structures shown in Fig. 4 of Willson are imaging polymers and while monomer structures, such as those in accordance with Formula A recited in Claim 1, might be used to form the aforementioned Willson polymers, one of ordinary skill in the art would certainly distinguish the photoresist polymer resins of Willson from the oligomeric dissolution rate modifiers of the present invention.

B. The differences between a polymeric binder resin such as disclosed by Willson, and an oligomeric DRM in accordance with the present invention, is readily seen by even the

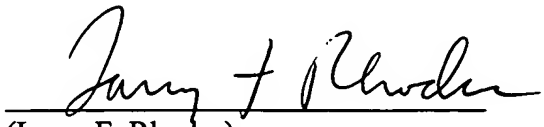
most casual observer ... yet alone a skilled artisan ... when both are cast onto a substrate, for example a silicon wafer (see, Exhibit C, C-11 and C-12). In particular, casting equal weight percent solutions of a polymer and an oligomer onto substrates to form films, results in films that have markedly different appearance and physical characteristics (see, the color fringing indicating poor uniformity for film formed from oligomer solution and the result after baking that the film thickness of the oligomer formed film decreases by greater than 75%, whereas the thickness of the polymer formed film decreases only by an average of 3%. Therefore, oligomeric DRMs cannot be used to form good quality films, and cannot be used as binder resins for photoresists, as disclosed in Willson. Indeed, the following citation of Hung et al. (citation # 4 in the cited Willson article) (Proceedings of SPIE, 2001, 4345, 385) indicates that Willson did not know, at the time the article was written and published, how to make oligomers, i.e., compounds having a molecular weight of less than 3,000:

> "The use of typical chain transfer agents on the polymerization of monomer 9 was unsuccessful... Addition of 1-hexene did not reduce the molecular weight of the polymer to an acceptable degree..."

C. With regard to Feiring, such published application does not provide any disclosure regarding oligomers and never even mentions the term. Rather, like Willson, Feiring only speaks to polymers and methods for making.

Finally:

I declare further that all statements made herein of my own knowledge are true and that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application and any patent issuing thereon.



(Larry F. Rhodes)

Date 11/14/06

# Larry F. Rhodes

## Publications

1. "Optical Density at 193 nm of Vinyl Addition Poly(norbornene) Made Using Hydrogen as a Chain Transfer Agent", C. Chang, J. Lipian, C. Burns, L. F. Rhodes, R. Lattimer, manuscript in preparation
2. "Fluorinated Aryl Nickel Complexes Containing Labile Ether Ligands. Synthesis, Solution Behavior, and X-Ray Crystal Structures" H. A. Kalamarides, S. Iyer, A. Cooper, G. M. Benedikt, L. F. Rhodes, C. Day, V. Day, manuscript in preparation.
3. "The Effect of End Group Modification on the Transparency of Vinyl Addition Norbornene Polymers at 193 nm" C. Chang, J. Lipian, D. A. Barnes, L. Seger, C. Burns, B. Bennett, L. Bonney, L. F. Rhodes, G. M. Benedikt, R. Lattimer, S. S. Huang, V. W. Day, Macromol. Chem .Phys. 2005, 206, 1988.
4. "The First Structurally Characterized Homoleptic Aryl-Manganese(III) Compound and the Corresponding Isoleptic and Isoelectronic Chromium(II) Derivative", J. Fornies, A. Martin, L. F. Martin, B. Menjon, H. Zhen, A. Bell, L. F. Rhodes, Organometallics, 2005, 24, 3266.
5. "Development of Optically Transparent Cyclic Olefin Photoresist Binder Resins" L. F. Rhodes, C. Chang, C. Burns, D. A. Barnes, B. Bennett, L. Seger, X. Wu, A. Sobek, M. Mishak, C. Peterson, L. Langsdorf, H. Hada, H. Shimizu, K. Sasaki, Proc. SPIE. Int. Soc. Opt. Eng., 2005, 5753, 149.
6. "Fluoropolymer Resists: Fundamentals and Lithographic Evaluation" H. Ito; H. D. Truong; L. F. Rhodes; C. Chang; L. J. Langsdorf; H. A. Sidaway; K. Maeda; S. Sumida J. Photopolym. Sci. Tech. 2004, 17(4), 609.
7. "Synthesis and Properties of Vinyl-Addition Polymerized Polynorbornene Electro-Optic Materials" K. H. Park, R. J. Twieg, R. Ravikiran, R. A. Shick, L. F. Rhodes, D. Yankelovich, A. Knoesen, Macromolecules 2004, 37, 5163.
8. "Bis-Trifluoromethyl Carbinol Substituted Polynorbornenes: Dissolution Behavior" T. Hoskins, W. J. Chung, A. Agrawal, P. J. Ludovice, C. L. Henderson, L. D. Seger, L. F. Rhodes, R. A. Shick, Macromolecules 2004, 37, 4512.
9. "Recent Progress on New Fluorinated Resins for 157 nm Lithography" F. Houlihan, R. Sakamuri, D. Rentkiewicz, A. Romano, R. R. Dammel, M. Sebald, N. Stepanenko, C. Hohle, L. Rhodes, J. McDaniel, C. Chang in "Advances in Imaging Materials and Processes", Eds. H. Ito, P. R. Varanasi; M. M. Khojasteh; R. Chen, Society of Plastics Engineers, 2004, 43.
10. "Dissolution Rate Modifiers Based on Oligomeric Norbornene Derivatives for Use in Chemically Amplified Cyclic Olefin Resists" L. D. Seger, C. Chang, X. Wu, D. A. Barnes, L. F. Rhodes, T. Hoskins, A. Jeyakumar, C. Henderson, R. R. Dammel in "Advances in Imaging Materials and Processes", Eds. H. Ito, P. R. Varanasi; M. M. Khojasteh; R. Chen, Society of Plastics Engineers, 2004, 53.
11. "Fabrication of Microchannels using Polynorbornene Photosensitive Sacrificial Materials" X. Wu, H. A. Reed, Y. Wang, L. F. Rhodes, E. Elce, R. Ravikiran, R. A. Shick, C. L. Henderson, S. A. Bidstrup Allen, P. A. Kohl Journal of the Electrochemical Society 2003, 150, H205.
12. "New Fluorinated Resins for 157 nm Lithography Application" F. Houlihan, A. Romano, D. Rentkiewicz, R. Sakamuri, R. R. Dammel, W. Conley, G. Rich, D. Miller, L. Rhodes, J. McDaniel, C. Chang J. Photopolym. Sci. Technol. 2003, 16(4), 581-590.
13. "Baking study of fluorinated 157 nm resists" F. Houlihan, R. Sakamuri, A. Romano, R. R. Dammel, W. Conley, G. Rich, D. Miller, L. F. Rhodes, J. McDaniel, C. Chang Proc. SPIE. Int. Soc. Opt. Eng., 2003, 5038, 641.
14. "Evaluation of novel fluorinated resist matrices for 157 nm lithography" F. Houlihan, D. Rentkiewicz, R. Sakamuri, A. Romano, R. R. Dammel, W. Conley, G. Rich, D. Miller, L. F. Rhodes, J. McDaniel, C. Chang Proc. SPIE. Int. Soc. Opt. Eng., 2003, 5039, 22.
15. "Hydrogen bonding and aqueous base dissolution behavior of hexafluoroisopropanol-bearing polymers" H. Ito, W. Hinsburg, L. F. Rhodes, C. Chang, Proc. SPIE. Int. Soc. Opt. Eng., 2003, 5039, 70.

16. "Dissolution behavior of bis-trifluoromethyl carbinol substituted polynorbornenes" T. Hoskins, W. J. Chung, P. J. Ludovice, C. L. Henderson, L. D. Seger, L. F. Rhodes, R. A. Shick, Proc. SPIE. Int. Soc. Opt. Eng., 2003, 5039, 600.
17. "Air Channel Fabrication for Micromechanical Systems via Sacrificial Photosensitive Polycarbonates" J. P. Jayachandran, H. A. Reed, H. Zhen, L. F. Rhodes, C. L. Henderson, S. A. Bidstrup Allen, P. A. Kohl, J. Microelectromech. Systems 2003, 12(2), 147.
18. "Addition Polymerization of Norbornene-Type Monomers Using Neutral Nickel Complexes Containing Fluorinated Aryl Ligands" D. A. Barnes, G. M. Benedikt, B. L. Goodall, S. Huang, H. A. Kalamarides, S. Lenhard, L. H. McIntosh III, K. T. Selvy, R. A. Shick, L. F. Rhodes, Macromolecules 2003, 36, 2623-2632.
19. "Photoinitiation systems and thermal decomposition of photodefinable sacrificial materials." X. Wu, H. A. Reed, L. F. Rhodes, E. Elce, R. Ravikiran, R. A. Shick, C. L. Henderson, S. A. Bidstrup Allen, P. A. Kohl, J. Appl. Polym. Sci. 2003, 88(5), 1186-1195.
20. "Fabrication of microchannels for compliant wafer level packaging using sacrificial materials" J. P. Jaychandran, H. A. Reed, H. Zhen, L. F. Rhodes, C. L. Henderson, S. A. Bidstrup Allen, P. A.Kohl, Proc. SPIE. Int. Soc. Opt. Eng., 2003, 4979(1), 287-294.
21. "High-Performance Plastic Substrates for Flexible Flat Panel Displays" S. Angiolini, M. Avidano, C. Barlocco, R. Bracco, J. J. Bacskay, J.-H. Lipian, P. S. Neal, L. F. Rhodes, R. A. Shick, X.-M. Zhao, G. Freeman, Proc. Eurodisplay (The 22nd International Display Research Conference) 2002, LN-19b, 907-910.
22. "Chemically Bonded Porogens in Methylsilsesquioxane. Part II: Electrical, Optical and Mechanical Properties" A. M. Padovani, L. Riester, L. F. Rhodes, S. A. Bidstrup Allen, P. A. Kohl, Journal of the Electrochemical Society 2002, 149(12), F171.
23. "Chemically Bonded Porogens in Methylsilsesquioxane. Part I: Structure and Bonding" A. M. Padovani, L. F. Rhodes, S. A. Bidstrup Allen, P. A. Kohl, Journal of the Electrochemical Society 2002, 149(12), F161.
24. "Addition Polymerization of Norbornene-Type Monomers. High Activity Cationic Allyl Palladium Catalysts" J. Lipian, R. A. Mimna, J. C. Fondran. D. Yandulov, B. L. Goodall, L. F. Rhodes, R. A. Shick,J. C. Huffman, Macromolecules 2002, 35(24), 8969-8977.
25. "Copolymerization of Ethene with Norbornene Derivatives Using Neutral Nickel Catalysts" G. M. Benedikt, E. Elce, B. L. Goodall, H. A. Kalamarides, L. H. McIntosh III, L. F. Rhodes, K. T. Selvy, C. Andes, K. Oyler, A. Sen, Macromolecules 2002, 35(24), 8978-8988.
26. "Synthesis and Characterization of a New Family of Square-Planar Nickel(II) Carbonyl Derivatives" J. Fornies, A. Martin, F. Martin, B. Menjon, H. A. Kalamarides, L. F. Rhodes, V. W. Day, C. S. Day, Chemistry: A European Journal 2002, 8, 4925.
27. "Lithographic Characteristics and Thermal Processing of Photosensitive Sacrificial Materials" X. Wu, H. A. Reed, L. F. Rhodes, E. Elce, R. Ravikiran, R. A. Shick, C. L. Henderson, S. A. Bidstrup-Allen, P. A. Kohl, J. Electrochem. Soc. 2002, 149(10), G555-G561.
28. "Cycloolefin/Cyanoacrylate (COCA) Copolymers for 193 and 157 nm Lithography" R. R. Dammel, R. Sakamuri, S.-H. Lee, M. D. Rahman, T. Kudo, A. Romano, L. F. Rhodes, J. Lipian, C. Hacker, D. A. Barnes, Proc. SPIE. Int. Soc. Opt. Eng., 2002, (Pt. 1, Advances in Resist Technology and Processing XIX), 4690, 101-109.
29. "Porous methylsilsequioxane for low-k dielectric applications" A. M. Padovani, L. Rhodes, L. Riester, G. Lohman, B. Tsuie, J. Conner, S. A. Bidstrup-Allen, P. A. Kohl. Electrochem. Solid-State Lett. 2001, 4(11), F25.
30. "New resin systems for 157 nm lithography" R. R. Dammel, R. Sakamuri, T. Kudo, A. Romano, L. Rhodes, R. Vicari, C. Hacker, W. Conley, D. Miller, J. Photopolym. Sci. Technol. 2001, 14(4), 603-612.
31. "A Novel, Efficient Pd-based System for the Polymerization of Norbornene Derivatives: Scope and Mechanism"
32. A. Hennis, J. Polley, A. Sen, D. Yandulov, J. Lipian, G. Benedikt, L. F. Rhodes, J. Huffman, Organometallics 2001, 20, 2802.

33. "Synthesis, Solution Dynamics and X-ray Crystal Structure of Ni(2,4,6-(tris(trifluoromethyl)phenyl)2(1,2-dimethoxyethane)" G. M. Benedikt, B. L. Goodall, S. Iyer, L. H. McIntosh III, R. Mimna, L. F. Rhodes, V. Day, C. Day, Organometallics 2001, 20, 2565.
34. "Fabrication of air-gaps between Cu interconnects for low intralevel k" D. M. Bhusari, M. D. Wedlake, P. A. Kohl, C. Case, F. P. Klemens, J. Miner, B.-C. Lee, R. J. Gutmann, J. J. Lee, R. A. Shick, L. F. Rhodes, Mater. Res.Soc. Symp. Proc. 2000, 612.
35. "Pentafluorophenyl Transfer from Tris(pentafluorophenyl)boron to Nickel. Synthesis and X-Ray Crystal Structure of (PPh2CH2C(O)Ph)Ni(C6F5)2" H. A. Kalamarides, S. Iyer, J. Lipian, L. F. Rhodes, C. Day Organometallics, 2000, 19, 3983.
36. "High-Performance Polymeric Materials for Waveguide Applications" K. Glukh, J.-H. Lipian, R. Mimna, P. S. Neal, R. Ravikiran, L. F. Rhodes, R. A. Shick, X.-M. Zhao, Proc. SPIE-Int. Soc. Opt. Eng., 2000, 4106, 43.
37. "Low-k Porous Spin-on-glass" P. A. Kohl, A. Padovani, M. Wedlake, D. Bhusari, S. A. Bidstrup-Allen, R. Shick, L. F. Rhodes, Mater. Res. Soc. Symp. Proc. 1999, 565, 55.
38. "Avatrel Dielectric Polymers for HDP Applications" W. C. McDougall, S. Farling, R. Shick, S. Glukh, S. K. Jayaraman, L. F. Rhodes, R. Vicari, P. Kohl, S. A. Bidstrup-Allen, P. Chiniwalla, Proc. SPIE-Int. Soc. Opt. Eng. 1999, 3830(International Conference on High Density Packaging and MCMs, 1999), 17-20.
39. "Approaches to Etch-Resistant 193-nm Photoresists: Performance and Prospects" R. D. Allen, J. Opitz, Juliann, H. Ito, Hiroshi, T. I. Wallow, D. V. Casmier, R. A. DiPietro, P. J. Brock, G. Breyta, S. Ratnam, C. E. Larson, D. C. Hofer, P. R. Varanasi, A. M. Mewherter, S. Jayaraman, R. Vicari, L. F. Rhodes, S. Sun Proc. SPIE-Int. Soc. Opt. Eng., 1999, 3678 (Pt. 1, Advances in Resist Technology and Processing XVI), 66-77.
40. "Photodefinable cyclic olefin polymers as interlevel dielectric material for microelectronic applications" S. Jayaraman, S. Sun, W.C. McDougall, L.F. Rhodes, R.A. Shick, P.A. Kohl, S.A. Bidstrup-Allen, Y. Bai Proceedings of the American Chemical Society Division of Polymeric Materials: Science and Engineering, 1999, 81, 71-72.
41. "Novel Transition Metal Catalyzed Cyclic Olefin Addition Polymers for 193 nm and 248 nm Resists"S. Jayaraman, R. Vicari, S. Sun, L. Rhodes, R. D. Allen, P. R. Varanasi, T. I. Wallow, J. Opitz, H. Ito, R. A. DiPietro, D. C. Hofer Proceedings of the American Chemical Society Division of Polymeric Materials: Science and Engineering, 1999, 80, 489.
42. "Structure-Property Relationships of Advanced Photoresist Materials in Reactive Ion Etch Processing" T. I. Wallow, P. J. Brock, R. A. DiPietro, R. D. Allen, J. Opitz, D. C. Hofer, A. Mewherter, W. Moreau, Y. Cui, W. Wan, J. Meute, J. Byers, G. Rich, M. McCallum, S. Jayaraman, R. Vicari, J. Cagle, K. Hullihen, L. Rhodes, B. Goodall, Proceedings of the American Chemical Society Division of Polymeric Materials: Science and Engineering, 1999, 80, 490.
43. "Approach to Etch-Resistant 193-nm Photoresists: Perfomance and Prospects" D. Allen, J. Opitz, H. Ito, T. I. Wallow, R. A. DiPietro, R. Sooriyakumaran, D. C. Hofer, P. R. Varanasi, A. M. Mewherter, S. Jayaraman, R. Vicari, K. A. Hullihen, L. F. Rhodes, S. Sun. Proceedings of SPIE's 24th International Symposium on Microlithography, Santa Clara, CA, 1999.
44. "Homo and Co-Polymers Derived from Multicyclic Olefin Monomers: The Quest for Higher Tg Materials" G. M. Benedikt, B. L. Goodall, L. H. McIntosh III, L. F. Rhodes, L. M. Wojcinski II in "Metallocene-Catalyzed Polymers" Eds. B. L. Goodall and G. M. Benedikt, Plastics Design Library, 1998, p. 57.
45. "Low k, Porous Methylsilsesquioxane and Hydrogensilsequioxane" A. T. Kohl, R. Mimna, R. Shick, L. F. Rhodes, Z. L. Wang, P. A. Kohl, Electrochemical and Solid-State Letters, 1999, 2(2), 77.
46. "AvatrelTM Dielectric Polymers for Electronic Packaging", R. A. Shick, S. Jayaraman, B. L. Goodall, L. F. Rhodes, W. C. McDougall, Adv. Microelectron. 1998, 25(5), 13.
47. "Platform-dependent Properties of 193 nm Single Layer Resists", R. A. Allen, T. I. Wallow, J. Opitz, C. Larson, R. A. DiPietro, R. Sooriyakumaran, P. Brock, G. Breyta, D. C. Hofer, S. Jayaraman, R. Vicari, K. A. Hullihen, L. F. Rhodes, B. L. Goodall, J. Photopolym. Sci. Technol. 1998, 11(3), 475.

48. "Advanced Materials for Electronic Applications by Polymerization of Cyclic Olefins Using Late Transition Metal Catalysts", D. A. Barnes, G. M. Benedikt, B. L. Goodall, K. Hullihen, S. Jayaraman, W. C. McDougall, L. H. McIntosh III, L. F. Rhodes, R. A. Shick, in Proceedings of MetCon '98 (Worldwide Metallocene Conference), Houston, TX Catalyst Consultants Inc., 1998.
49. "Novel Heat-Resistant Cyclic Olefin Polymers Made Using Single Component Nickel and Palladium Catalysts: Synthesis and Applications", B. L. Goodall, D. A. Barnes, G. M. Benedikt, S. Jayaraman, L. H. McIntosh, L. F. Rhodes, R. A. Shick, Polym. Prep. 1998, 39(1), 216.
50. "Design of an Etch-Resistant Cyclo-Olefin Photoresist for 193 nm Lithography", R. Allen, T. Wallow, J. Opitz, R. DiPietro, D. Hofer, S. Jayaraman, K. Hullihan, L. F. Rhodes, B. Goodall, R. Shick, Proc. SPIE-Int. Soc. Opt. Eng. 1998, 3333 (Pt. 1, Advances in Resist Technology and Processing XV), 463.
51. "Reactive Ion Etching of 193 nm photoresist candidates: An Assesment of Current Platforms and Future Production Requirements", R. Allen, T. Wallow, J. Opitz, R. DiPietro, D. Hofer, S. Jayaraman, K. Hullihan, L. F. Rhodes, B. Goodall, R. Shick, Proc. SPIE-Int. Soc. Opt. Eng. 1998, 3333 (Pt. 1, Advances in Resist Technology and Processing XV), 92.
52. "High Performance Cyclic Olefins for Wireless Applications", W. C. McDougall, R. A. Shick, S. Jayaraman, B. L. Goodall, L. F. Rhodes, P. Kohl. S. A. Bidstrup-Allen, P. Chiniwalla, Wireless Symposium Exhibition, Boston, MA, 1998.
53. "Novel Heat-Resistant Cyclic Olefin Polymers Made Using Single Component Nickel and Palladium Catalysts", B. L. Goodall, D. A. Barnes, G. M. Benedikt, L. H. McIntosh, L. F. Rhodes, in Proceedings of MetCon '97 (Worldwide Metallocene Conference), Houston, TX Catalyst Consultants Inc., 1997.
54. "Novel Heat-Resistant Cyclic Olefin Polymers Made Using Single Component Nickel and Palladium Catalysts", B. L. Goodall, D. A. Barnes, G. M. Benedikt, L. H. McIntosh, L. F. Rhodes, Proceedings of the American Chemical Society Division of Polymeric Materials: Science and Engineering, 1997, 76, 56.
55. "New Structural and Mechanistic Chemistry in Polymerizations of Vinyl Chloride Initiated by Di-tert-alkylmagnesiums", M. N. Bell, G. M. Benedikt, R. J. Cozens, B. L. Goodall, A. C. Kemball, L. F. Rhodes, W. H. Starnes, Jr. Macromolecules, 1997, 30, 10.
56. "Cyclic Olefin Copolymers. Strategies for Obtaining Higher Glass Transition Temperatures", G. M. Benedikt, B. L. Goodall, L. F. Rhodes, Lou M. Wojcinski II, in Proceedings of MetCon '95 (Worldwide Metallocene Conference), Houston, TX Catalyst Consultants Inc., 1995.
57. "Polymerization of Vinyl Chloride Using Di-t-Alkyl Group 2 Metal Initiators", G. M. Benedikt, R. J. Cozens, B. L. Goodall, L. F. Rhodes, M. N. Bell, A. C. Kemball, W. H. Starnes, Jr., in Proceedings of the American Chemical Society Division of Polymeric Materials: Science and Engineering, 1995, 73, 540.
58. "Homo- and Co-Polymers Derived from Multicyclic Olefin Monomers: The Quest for Higher Tg Materials", G. M. Benedikt, B. L. Goodall, L. H. McIntosh III, L. F. Rhodes, L. M. Wojcinski II, Proceedings of the Regional Technical Conference of the Society of Plastics Engineers (Polyolefins IX International Conference), February 26-March 1, 1995, Houston, TX.
59. "New Catalysts for the Polymerization of Cyclic Olefins", B. L. Goodall, L. H. McIntosh III, L. F. Rhodes, Macromol. Symp., 1995, 89, 421.
60. "The Reaction of Macroradicals with Alkene Chain Ends During the Polymerization of Vinyl Chloride", W. H. Starnes, H. Chung, R. D. Pike, B. J. Wojciechowski, V. G. Zaikov, G. M. Benedikt, L. F. Rhodes, B. L. Goodall, Polym. Prep., 1995, 36(2), 404.
61. "NMR Spectroscopy of Poly(Vinyl Chloride) Defects. 2. 1H NMR Analysis of the Vinyl End Group, 1,3-Dichlorobutyl End Group and Chloromethyl Branch", G. M. Benedikt, B. L. Goodall, L. F. Rhodes, A. C. Kemball, Macromol. Symp. 1994, 86, 65.
62. "Routes to High Glass Transition Temperature Cyclic Olefin Based Thermoplastics", G. M. Benedikt, B. L. Goodall, N. S. Marchant, L. F. Rhodes, in Proceedings of MetCon '94 (Worldwide Metallocene Conference), Houston, TX Catalyst Consultants Inc., 1994.

63. "Polymerization of Multicyclic Monomers Using Zirconocene Catalysts. Effect of Polymer Microstructure on Thermal Properties", G. M. Benedikt, B. L. Goodall, N. S. Marchant, L. F. Rhodes, New J. Chem., 1994, 18, 105.
64. "Novel Catalysts for the Ring-Opening Metathesis Polymerization of Norbornene-Type Monomers: Catalyst Systems Tailored for RIM Applications", B. L. Goodall, W. J. Kroenke, R. J. Minchak, L. F. Rhodes, in Proceedings of the Third International Business Forum on Specialty Polyolefins '93 (SPO '93), Houston, TX, Schotland Business Research, 1993, p. 381.
65. "Zirconocene Catalyzed Copolymerization of Multicyclic Olefins: NMR Characterization of Copolymers of Tetracyclododecene and Ethylene", G. M. Benedikt, B. L. Goodall, N. S. Marchant, L. F. Rhodes, in Proceedings of MetCon '93 (Worldwide Metallocene Conference), Houston, TX Catalyst Consultants Inc., 1993, p. 427.
66. "Novel Catalysts for the Ring-Opening Metathesis Polymerization of Norbornene-Type Monomers", B. L. Goodall, W. J. Kroenke, R. J. Minchak, L. F. Rhodes, J. Appl. Polym. Sci., 1993, 47, 607.
67. "Heterometallic Species Containing Cp2MH2 (M = Mo and W) and Cu+ or Ag+ are Inner Sphere Redox Intermediates", L. F. Rhodes, J. C. Huffman, K. G. Caulton, Inorg. Chim. Acta 1992, 200, 639.
68. "A Heterometallic Cluster With Extreme Hydride Content: H24Cu6Re4(PPh3)82+" L. F. Rhodes, R. L. Bansemer, K. Folting, J. C. Huffman, K. G. Caulton, Inorg. Chim. Acta 1992, 191, 31.
69. "The Transient Radical H3Ir(PMe2Ph)3+: A Bronsted Acid", D. E. Westerberg, L. F. Rhodes, J. Edwin, W. E. Geiger, K. G. Caulton, Inorg. Chem. 1991, 30, 1107.
70. "Bonding in Tris(η5-cyclopentadienyl) Actinide Complexes. 4. Electronic Structural Effects in AnCl3 and (η5-C5H5)3An (An = Th -Cf) Complexes", B. E. Bursten, L. F. Rhodes, R. J. Strittmatter, J. Less Comm. Met. 1989, 149, 207.
71. "Bonding in Tris(η5-cyclopentadienyl) Actinide Complexes. 3. Interaction of-Neutral, -Acidic, and -Basic Ligands with (η5-C5H5)3U", B. E. Bursten, L. F. Rhodes, R. J. Strittmatter, J. Am. Chem. Soc. 1989, 111, 2758.
72. "Bonding in Tris(η5-cyclopentadienyl) Actinide Complexes. 2. On the Ground Electronic Configurations of "Base-Free" Cp3An Complexes (An = Th, Pa, U, Np, Pu)", B. E. Bursten, L. F. Rhodes, R. J. Strittmatter, J. Am. Chem. Soc. 1989, 111, 2756.
73. "Gold-Rhodium and Gold-Iridium Hydride Clusters", A. Albinati, F. Demartin, P. Janser, L. F. Rhodes, and L. M. Venanzi, J. Am. Chem. Soc. 1989, 111, 2115.
74. "Ruthenium(II) Solvento Complexes Containing the Tripod-Like Ligands MeC(CH2EPh2)3 (E = P or As) and Their Reactions with Carbon Monoxide. Crystal and Molecular Structure of [Ru2(μ-Cl)3(MeC(CH2PPh2)3)2][BPh4]", L. F. Rhodes, C. Sorato, L. M. Venanzi, F. Bachechi, Inorg. Chem. 1988, 27, 604.
75. "Ruthenium(II) Assisted Borohydride Reduction of Acetonitrile", L. F. Rhodes, L. M. Venanzi, Inorg. Chem., 1987, 26, 2692.
76. "A Bimetallic Ruthenium Hydride Borohydride Complex with Unusually Short Ruthenium-Boron Distances. The X-Ray Crystal Structure of [(tripod)HRu(μ,η2-BH4)RuH(tripod)]BPh4 (tripod = MeC(CH2PPh2)3)", L. F. Rhodes, L. M. Venanzi, C. Sorato, A. Albinati, Inorg. Chem., 1986, 25, 3335.
77. "Synthesis, Characterization, and Reactivity of Some Rhenium Phosphite Complexes", L. F. Rhodes, K. G. Caulton, W. K. Rybak, J. J. Ziolkowski, Polyhedron, 1986, 5, 1891.
78. "Assay of Hydride or Other Gaseous Ligands via Outer-Sphere Oxidation", T. H. Lemmen, E. G. Lundquist, L. F. Rhodes, B. R. Sutherland, D. E. Westerberg, K. G. Caulton, Inorg. Chem., 1986, 25, 3915.
79. "Rational Synthesis of Copper Polyhydride Complexes", K. G. Caulton, G. V. Goeden, T. H. Lemmen, L. F. Rhodes, J. C. Huffman, in "Biological and Inorganic Copper Chemistry", (K. D. Karlin and J. Zubieta, eds.) Adenin Press, 1985.

80. "Multiple Mixed-Metal Condensation Leading to the Pentagonal Bipyramidal Hexahydride, Ir2Cu3H6(MeCN)3(PMe2Ph)6(PF6)3", L. F. Rhodes, J. C. Huffman, K. G. Caulton, J. Am. Chem. Soc., 1985, 107, 1759.
81. "IrH4(PMe2Ph)3+: Its Characteristic Reactivity and Use as a Catalyst for Isomerization of IrH3(PMe2Ph)3". L. F. Rhodes and K. G. Caulton, J. Am. Chem. Soc., 1985, 107, 259.
82. "Copper(I) and Silver(I)-Diiridium Polyhydrides", L. F. Rhodes, J. C. Huffman, K. G. Caulton, J. Am. Chem. Soc., 1984, 106, 6874.
83. "An Unprecedented Ligand Set and Coordination Geometry for Cu(I)", L. F. Rhodes, J. C. Huffman, K. G. Caulton, J. Am. Chem. Soc., 1983, 105, 5137.
84. "Electrophilic Attack as Route to Coordinative Unsaturation", L. F. Rhodes, M. A. Green, J. C. Huffman, K. G. Caulton, in "Chemistry and Uses of Molybdenum", (H.F. Barry and P. C. H. Mitchell, eds.) Climax Molybdenum Co., Ann Arbor, MI, 1982.
85. "Oxidation and Acidolysis of MoH4(PR3)4", L. F. Rhodes, J. D. Zubkowski, K. Folting, J. C. Huffman, K. G. Caulton, Inorg. Chem., 1982, 21, 4185.

## ***Patents and Patent Applications***

1. "Heteropolymetallate Metathesis Catalysts for Cycloolefin Polymerization", US 4923936, B. L. Goodall and L. F. Rhodes, 1990 (filed 1989) to B. F. Goodrich Co.
2. "Pyridinium Metathesis Catalysts for Cycloolefin Polymerization", US 5066740, L. F. Rhodes, 1991 (filed 1990) to B. F. Goodrich Co.
3. "Addition Polymers Derived from Norbornene-functional Monomers and Process Therefor", WO 9514048, B. L. Goodall, D. A. Barnes, G. M. Benedikt, L. H. McIntosh, L. F. Rhodes. 1996 (filed 1994) to B. F. Goodrich Co.
4. "Addition Polymers Derived from Norbornene-functional Monomers and Process Therefor", US 5569730, B. L. Goodall, D. A. Barnes, G. M. Benedikt, L. H. McIntosh, L. F. Rhodes, 1996 (filed 1994) to B. F. Goodrich Co.
5. "Addition Polymers Derived from Norbornene-functional Monomers and Process Therefor", US 5571881, B. L. Goodall, D. A. Barnes, G. M. Benedikt, L. H. McIntosh, L. F. Rhodes, 1996 (filed 1994) to B. F. Goodrich Co.
6. "Addition Polymers Derived from Norbornene-functional Monomers and Process Therefor", US 5741869, B. L. Goodall, D. A. Barnes, G. M. Benedikt, L. H. McIntosh, L. F. Rhodes, 1998 (filed 1995) to B. F. Goodrich Co.
7. "Reaction Injection Molding (RIM) of Methyl (Meth)acrylate and Related Monomers Using Group 4 Catalysts", US 5668234, L. F. Rhodes, B. L. Goodall, S. Collins, 1997 (filed 1994) to B. F. Goodrich Co.
8. "Method for the preparation of copolymers of ethylene/norbornene-type monomers with nickel catalysts", US 5929181, K. L. Makovetsky, E. S. Finkelshtein, V. I. Bykov, A. K. Bagdasaryan,B. L. Goodall, L. F. Rhodes, 1999 (filed 1997) to B. F. Goodrich Co.
9. "Photoresist composition comprising polycyclic polymer with acid labile pendant groups", US 6136499, B. L. Goodall, S. Jayaraman, R. A. Shick, L. F. Rhodes, 2000 (filed 1997) to B. F. Goodrich Co.
10. "Polycyclic resist compositions with increased etch resistance", US 6147177, S. Jayaraman, B. L. Goodall, L. F. Rhodes, R. A. Shick, R. Vicari, R. D. Allen, J. Opitz, R. Sooriyakumaran; T. Wallow, 2000 (filed 1999) to B. F. Goodrich and IBM.
11. "Method for the preparation of copolymers of ethylene/norbornene-type monomers with nickel catalysts", US 6197984, K. L. Makovetsky, E. S. Finkelshtein, V. I. Bykov, A. K. Bagdasaryan, B. L. Goodall, L. F. Rhodes, 2001 (filed 1997) to B. F. Goodrich Co.

12. "Polycyclic polymers for photoresists", US 6147177, S. Jayaraman, B. L. Goodall, L. F. Rhodes, R. A. Shick, R. Vicari, R. D. Allen, J. Opitz, R. Sooriyakumaran; T. Wallow, 2001 (filed 1999) to B. F. Goodrich and IBM.
13. "Photoresist compositions comprising polycydic polymers with acid labile pendant groups", US 6232417, L. F. Rhodes, A. Bell, S. Jayaraman, J.-H. Lipian, B. L. Goodall, R. A. Shick, 2001 (filed 1997) to B. F. Goodrich.
14. "Method of preparing norbornene sulfonamide polymers", US 6235849, S. Jayaraman,R. Vicari, L. F. Rhodes, 2001 (filed 1999) to B. F. Goodrich.
15. "Blends and Alloys of Polycyclic Polymers", US 6294616, L. F. Rhodes, B. L. Goodall, R. Mulhaupt, R. A. Shick, G. M. Benedikt, S. Jayaraman, L. M. Soby, L. H. McIntosh III, 2001 (filed 1995) to B. F. Goodrich.
16. "Norbornene sulfonamide polymers", US 6420503, S. Jayaraman, R. Vicari, L. F. Rhodes, P. Varanasi; R. Sooriyakumaran, R. D. Allen, R. A. Dipietro, H. Ito, J. Opitz, 2002 (filed 1999) to B. F. Goodrich and IBM.
17. "Mold addition polymerization of norbornene-type monomers using group 10 metal complexes", US 6350832 B1, A. Bell, L. F. Rhodes, B. L. Goodall, J. Fondran, 2002 (filed 1999) to B. F. Goodrich Co.
18. "Polycyclic resist compositions with increased etch resistance", US 6451499 B1, S. Jayaraman, B. L. Goodall, L. F. Rhodes, R. A. Shick, R. Vicari, R. D. Allen, J. Opitz, R. Sooriyakumaran; T. Wallow, 2002 (filed 2000) to B. F. Goodrich and IBM.
19. "Modified polycyclic polymers", US 6451945 B1, S. Jayaraman, G. M. Benedikt, L. F. Rhodes, R. Vicari, R. D. Allen, R. DiPietro, R. Sooriyakumaran; T. Wallow, 2002 (filed 1999) to B. F. Goodrich and IBM.
20. "Catalyst and methods for polymerizing cycloolefins", US 6455650 B1, J.-H. Lipian, L. F. Rhodes, B. L. Goodall, A. Bell, R. Mimna, J. C. Fondran, S. Jayaraman, A. D. Hennis, C. N. Elia, J. D. Polley, A. Sen, 2002 (1999) to B. F. Goodrich and the Penn State Research Foundation.
21. "Polymeric compositions for forming optical waveguides; optical waveguides formed therefrom; and methods for making same", US 6538087 B2, X.-M. Zhao, R. Ravikiran, P. S. Neal, R. A. Shick, L. F. Rhodes, A. Bell, 2003 (filed 2001) to Promerus.
22. "Blends and Alloys of Polycyclic Polymers", US 6649707 B1, L. F. Rhodes, B. L. Goodall, R. Mulhaupt, R. A. Shick, G. M. Benedikt, S. Jayaraman, L. M. Soby, L. H. McIntosh III, 2001 (filed 2000) to Sumitomo Bakelite.
23. "Photoresist composition comprising polycyclic polymer with acid labile pendant groups", US 6723486, B. L. Goodall, S. Jayaraman, R. A. Shick, L. F. Rhodes, R. D. Allen, R. A. DiPietro, T. Wallow, 2004 (filed 2000) to Sumitomo Bakelite and IBM.
24. "Photoresist composition comprising polycyclic polymer with acid labile pendant groups", US 6790579 B1, B. L. Goodall, S. Jayaraman, R. A. Shick, L. F. Rhodes, 2004 (filed 2001) to Sumitomo Bakelite.
25. "Modified polycyclic polymers", US 6794459 B2, S. Jayaraman, G. M. Benedikt, L. F. Rhodes, R. Vicari, R. D. Allen, R. A. DiPietro, R. Sooriyakumaran, T. Wallow, US 6794459 B2, 2004 (filed 2002) to Sumitomo Bakelite and IBM.
26. "Polymerized cycloolefins using transition metal catalyst and end products thereof", US 6903171, L. F. Rhodes, A. Bell, R. Ravikiran, J. C. Fondran, S. Jayaraman, B. L. Goodall, R. A. Mimna, J.-H. Lipian, 2005 (filed 2002) to Promerus.
27. "Mold addition polymerization of norbornene-type monomers using group 10 metal complexes", US 6936672 B2, A. Bell, L. F. Rhodes, B. L. Goodall, J. Fondran, 2005 (filed 1999) to Sumitomo Bakelite
28. "Polymeric Compositions and Uses Therefor", L. F. Rhodes, R. Vicari, L. J. Langsdorf, A. A. Sobek,E. P. Boyd, B. Bennett, US 6949609, 2005 (filed 2001) to Sumitomo Bakelite.
29. "Photosensitive compositions based on polycyclic polymers", US 7022790 E. Elce, T. Hirano, J. C. Krotine, L. F. Rhodes, B. L. Goodall, S. Jayaraman, W. C. McDougall, S. Sun, 2006 (filed 2003) to Sumitomo Bakelite.

30. "Photo-imageable compositions of norbornene and acrylate copolymers and use thereof", US 7087691, L. F. Rhodes, L. Seger, A. H. Marchetti, A. Sen, 2006 (filed 2003) to Promerus and Penn State University Research Foundation.
31. "Norbornene-type monomers and polymers containing pendent lactone or sultone groups", US 7101654, X. Wu, L. F. Rhodes, L. Seger, 2006 (filed 2004) to Promerus.
32. "Method of controlling the differential dissolution rate of photoresist compositions, polycyclic olefin polymers and monomers used for making such polymers", US 20040166436, L. F. Rhodes, C. Chang, L. J. Langsdorf, H. A. Sidaway, H. Ito, 2004 (filed 2003) to Sumitomo Bakelite and IBM.
33. "Vinyl addition polycyclic olefin polymers prepared with non-olefinic chain transfer agents and their uses in photoresist", US20040229157 L. F. Rhodes, D. A. Barnes, A. Bell, B. K. Bennett, C. Chang, J.-H. Lipian, X. Wu, 2004 (filed 2003) to Promerus LLC.
34. "Dissolution rate modifiers for photoresist compositions", US 20040219452, L. F. Rhodes, L. Seger, B. L. Goodall, L. H. McIntosh, R. J. Duff, 2004 (filed 2003) to Promerus LLC.
35. "Polycyclic polymers containing pendant ion conducting moieties", US 20050019638 R. Ravikiran, X. Wu, L. Rhodes, R. Shick, H. Nakano, H. Nonaka, H. Wang, S. Jayaraman, R. Duff, J.-H. Lipian, 2005 (filed 2003) to Promerus LLC.
36. "Norbornene-type monomers and polymers containing pendent lactone or sultone groups", US 20050153240, X. Wu, L. F. Rhodes, L. Seger, (filed 2004) to Promerus.
37. "Directly photodefinable polymer compositions and methods thereof", US 20050186502, E. Elce, R. Ravikiran, L. F. Rhodes, R. A. Shick, S. Jayaraman (filed 2004) to Promerus.
38. "Polymers of Polycyclic Olefins having a Polyhedraloligosilsequioxane Pendant Group and Uses Thereof", US 20050192409, L. F. Rhodes, L. Seger, R. Ravikiran, E. Elce, R. Shick, J-H. Lipian, (filed 2004) to Promerus.
39. "Polymeric compositions and uses therefor", L. F. Rhodes, R. Vicari, L. J. Langsdorf, A. A. Sobek, E. P. Boyd, B. Bennett, US 20060025540, 2006 (filed 2005) to Sumitomo Bakelite
40. "Polycycloolefin polymeric compositions for semiconductor applications", R. Ravikiran; H. Ng. R. R. Puthenkovilakom, L. Zhang, D. Amoroso, B. Knapp, A. Bell, L. F. Rhodes, US 2006041093.
41. "Polymeric Compositions and Uses Therefor", L. F. Rhodes, R. Vicari, L. J. Langsdorf, A. A. Sobek, E. P. Boyd, B. Bennett, WO03050158, 2003 (2001) to Sumitomo Bakelite.
42. "Polymerized cycloolefins using transition metal catalyst and end products thereof", L. F. Rhodes, A. Bell, R. Ravikiran, J. Fondran, S. Jayaraman, B. Goodall, R. Mimna, J. Lipian, WO2004035636, 2002 (2004) to Promerus.
43. "Optical waveguides and methods thereof", K. Choki, M. Tetsuya, R. Ravikiran, M. Fujiwara, K. Takahama, K. Watanabe, H. Nonaka, Y. Otake, A. Bell, L. Rhodes, D. Amoroso, M. Matsuyama, WO2005052641, 2005 (2004) to Sumitomo Bakelite.
44. "Norbornene-type polymers, compositions thereof and lithographic processes using such compositions", L. F. Rhodes, C. Chang, P. Kandanarachchi, L. D. Seger, K. Ishiduka, K. Endo, T. Ando, WO2006091523, 2006 (2005) to Promerus and TOK.
45. "Norbornene-type polymers, compositions thereof and lithographic processes using such compositions", L. F. Rhodes, C. Chang, P. Kandanarachchi, L. D. Seger, K. Ishiduka, K. Endo, T. Ando, WO2006091802, 2006 (2005) to Promerus and TOK.

# MOLECULES AND MOLECULAR STRUCTURE

## 1.1 macromolecule

## polymer molecule

A molecule of high relative molecular mass, the structure of which essentially comprises the multiple repetition of units derived, actually or conceptually, from molecules of low relative molecular mass.

*Notes*

1. In many cases, especially for synthetic polymers, a molecule can be regarded as having a high relative molecular mass if the addition or removal of one or a few of the units has a negligible effect on the molecular properties. This statement fails in the case of certain macromolecules for which the properties may be critically dependent on fine details of the molecular structure.
2. If a part or the whole of the molecule has a high relative molecular mass and essentially comprises the multiple repetition of units derived, actually or conceptually, from molecules of low relative molecular mass, it may be described as either **macromolecular** or **polymeric**, or by **polymer** used adjectivally.

## 1.2 oligomer molecule

A molecule of intermediate relative molecular mass, the structure of which essentially comprises a small plurality of units derived, actually or conceptually, from molecules of lower relative molecular mass.

*Notes*

1. A molecule is regarded as having an intermediate relative molecular mass if it has properties which do vary significantly with the removal of one or a few of the units.
2. If a part or the whole of the molecule has an intermediate relative molecular mass and essentially comprises a small plurality of units derived, actually or conceptually, from molecules of lower relative molecular mass, it may be described as **oligomeric**, or by **oligomer** used adjectivally.

## 1.3 monomer molecule

A molecule which can undergo polymerization thereby contributing constitutional units to the essential structure of a macromolecule.

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